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Coral in Alaska: Distribution, abundance, and species associations

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Abstract - To help identify fishery management actions that minimize the adverse impacts of fishing activities on corals in Alaska, the distribution and abundance of corals were analyzed based on trawl survey data collected during 1975 - 1998. We also examined the species of commercially managed fish that are associated with coral. Soft corals, primarily *Gersemia* sp., were the most frequently encountered corals in the Bering Sea. In the Aleutian Islands gorgonian corals, primarily in the genera *Callogorgia*, *Primnoa*, *Paragorgia*, *Fanellia* (= *Callogorgia*), *Thouarella*, and *Arthrogorgia* were the most common corals. In the Gulf of Alaska, gorgonian corals, primarily in the genera *Callogorgia* and *Primnoa*, and cup corals, primarily *Scleractinia* unidentified, occurred most frequently. The Aleutian Islands area appears to have the highest abundance and diversity of corals. Some fish groups are associated with particular types of coral. Rockfish (*Sebastes* spp. and *Sebastolobus alascanus*) and Atka mackerel (*Pleurogrammus monopterygius*) were the most common fish captured with gorgonian, cup, and hydro corals, whereas flatfish and gadids were the most common fish captured with soft corals.

Introduction

New provisions in the Magnuson - Stevens Act have increased emphasis on the protection of marine habitat (NMFS, 1996). Part of these provisions call for the identification and protection of Habitat Areas of Particular Concern (HAPC). HAPC are those geographic areas and types of habitat that have special importance and may require additional protection from adverse effects. HAPC are defined on the basis of ecological importance, sensitivity, vulnerability, and rarity of the habitat. In Alaska, corals, sea pens, sea whips, sea anemones, sponges, and other "living substrates" have been identified as HAPC.

There are five major taxonomic groups and at least 34 species of coral in Alaska (Cimberg et al., 1981). Following the taxonomic scheme in Brusca & Brusca (1990), the taxonomic groups found off Alaska are Alcyonacea (soft corals), Gorgonacea (sea fans, bamboo corals, and tree corals), Scleractinia (cup corals, stony corals, or true corals), Stylasterina (hydrocorals), and Antipatharia (black corals). In support of proposed measures to protect coral from the adverse impacts of fishing gear, we provide a compilation of information on the distribution and abundance of corals

in Alaska. Cimberg, *op. cit.* also provided a compilation based mostly on the literature, reference collection records, and personal communications. Our compilation updates and augments Cimberg, *op. cit.*, by using National Marine Fisheries Service (NMFS) trawl survey data. Also, we examine the association of commercially valuable fish species with coral. This study encompasses such a large volume of data and large geographic area that we take a large-scale approach to analyzing the data, relying in part on qualitative descriptions of the data.

Recently emphasis has been placed on protecting gorgonian coral from the adverse impacts of commercial fishing (Witherell and Coon, 2000). In Alaska, gorgonians, especially *Primnoa* (red tree coral) and *Paragorgia*, may be the most valuable, due to their large size (up to 3 m high and 7 m wide), relatively high abundance, and luster of the skeleton when polished as jewelry (i.e., *Primnoa*). Large *Primnoa* colonies may be hundreds of years old (Risk et al., 1998; Andrews et al., 2000). The habitat created by gorgonians can be occupied by communities with high biodiversity and can be sources of shelter for fish (Risk et al., 1988). Given their size and longevity, gorgonian corals may also be most vulnerable to fishing impacts.

Methods

The NMFS research survey data base, RACEBASE, includes records of research cruises since 1954. Cruises before 1975 were primarily exploratory efforts focusing on commercial fish species where coral may or may not have been recorded; thus, we do not include data before 1975. The survey area encompasses most of the continental shelf and upper slope of the Gulf of Alaska (GOA), Aleutian Islands, and the eastern Bering Sea in waters less than 1,000 m (Figure 1). Inside waters of the Alexander Archipelago (southeastern Alaska) and waters north of St. Lawrence Island were generally not surveyed. A few survey stations were located on the shelf area of the Chukchi Sea. Because of rough substrate, especially in the Aleutian Islands and off southeastern Alaska in the GOA, not all areas can be sampled with bottom trawls, the primary sampling gear.

We classified locations into three broad geographic areas by generally following the physical regions of Alaska in Orth (1967): Bering Sea, Aleutian Islands, and the GOA (Figure 1). The Aleutian Islands refers to the chain of islands separating the Bering Sea from the Pacific Ocean, extending from the southwestern tip of the Alaska Peninsula to the U.S.-Russia border west of Attu Island. Orth (1967) considered the GOA as the body of water bounded to the south by the southern tip of Dall Island in southeastern Alaska and to the west by the southern end of Kodiak Island. In this paper, we consider the GOA as bounded to the south by the U.S.-Canada border and to the west by the southwestern tip of the Alaska Peninsula.

Many coral names in the data base do not represent individual species but various levels of taxonomic groupings. The taxonomic level that a particular specimen of coral is keyed to depends on the expertise of scientists on an individual research cruise. Specimens are often brought back from the field where they can be verified. In the data base, the code 41500 was used to identify both "Gorgonacea (order)" and "coral unidentified" (NMFS, 1998). Because of this ambiguity, we assign all records of this code to coral unidentified. The taxonomy of Alaska corals is in question, and there are evidently some undescribed species present (Cimberg, *op. cit.*; Dr. J. W. Orr, NMFS, Seattle, WA, pers. com.).

To facilitate some analyses, coral records were consolidated into the five major taxonomic groups: black corals, gorgonian corals, hydrocorals, cup corals, and soft corals. The frequency of occurrence as well as catch per unit effort (CPUE) of corals were examined. Frequency of occurrence is the number of survey hauls in which a particular taxonomic level of coral occurred.

CPUE of coral in each haul was computed by dividing the weight of coral in kg (catch) by the duration in h (effort).

Cimberg, *op. cit.* provided a listing of the locations by latitude and longitude for coral. For some locations in Cimberg, *op. cit.* only a place name was given, not a latitude and longitude. For such cases, we assigned an approximate location by looking the place name up in Orth (1967). Cimberg, *op. cit.* did not provide estimates of abundance at each location nor the catch of other species.

For analysis of coral and fish associations based on trawl survey data, fish species were consolidated into five groups: flatfish (Bothidae and Pleuronectidae), gadids ((mostly walleye pollock (*Theragra chalcogramma*) and Pacific cod (*Gadus macrocephalus*)), Atka mackerel (*Pleurogrammus monopterygius*), rockfish (*Sebastes* spp. and *Sebastolobus alascanus*), and other fish ((mostly greenlings (Hexagrammidae), sablefish (*Anoplopoma fimbria*) and skates (Rajidae)). Abundance of fish species was standardized by computing CPUE (kg h⁻¹).

Results and Discussion

Since 1975, there have been 21,462 survey bottom trawl hauls (including "shrimp trawls") (Figure 1). Corals were recorded in 12.7% (2,725) of these hauls. The data included 44 taxonomic names for corals in Alaska (Table 1). Black corals were not found in any hauls. Soft corals occurred most frequently, in 72.5% of the hauls where corals were encountered, followed by gorgonian corals (18.7 %), cup corals (10.3%), hydrocorals (5.9%), and unidentified corals (4.8%).

When the data were broken down by geographic region, a pattern emerged (Figure 2). Soft corals, primarily *Gersemia* sp., were the most common corals in the Bering Sea (Table 1). Soft corals made up over 96% of the coral encountered in the Bering Sea. In the Aleutian Islands, soft corals were the least frequently encountered type. Only 21% of the corals encountered in the Aleutian Islands were soft corals. Gorgonian corals were the most common corals in the Aleutian Islands. About 46% of the coral encountered in the Aleutian Islands were gorgonian corals, primarily in the genera *Callogorgia*, *Primnoa*, *Paragorgia*, *Fanellia*, *Thouarella*, and *Arthrogorgia*. In the GOA, the most frequently encountered types were gorgonian (~45%, primarily *Callogorgia* and *Primnoa*) and cup corals (31%, mostly "Scleractinia unidentified").

The Aleutian Islands appeared to have the highest diversity of coral species (Table 1). Overall, there were 43 different taxonomic records in the

Aleutian Islands, whereas the Bering Sea and the GOA had 8 and 14 records, respectively.

Gorgonian corals exist throughout the Aleutian Islands, mostly in isolated patches in the GOA, and rarely in the eastern Bering Sea (Figure 3). In the Aleutian Islands, the area of their highest CPUE was in the western Aleutians (i.e., west of 180 degrees longitude) near Attu Island, Agattu Islands, and Kiska Islands, and in the eastern Aleutians near Amilia Island. In the GOA the highest CPUE of gorgonian coral was in the central GOA in the vicinity of the Kenai Peninsula and off southeastern Alaska in Dixon Entrance near the U.S.-Canada border. The few locations of gorgonian coral in the Bering Sea were along the outer continental shelf and shelf break near the Pribilof Islands and St. Matthew Island. In waters off Alaska, specific areas of high gorgonian coral abundance are being proposed as marine protected areas, where no commercial fishing will be allowed (Witherell and Coon, 2000). The results of our study are being used as a basis for these proposals.

Cup corals had a similar distribution to that of gorgonians (Figure 3). In the Aleutian Islands, the highest CPUE of cup corals was in the western Aleutians near Attu Island and Amchitka Island and in the eastern Aleutians near Tanaga, Amila, and Umnak Islands. In the GOA, their highest CPUE was in the central GOA off the Kenai Peninsula and in the eastern GOA off Yakutat and in Dixon Entrance.

Hydrocorals were generally found throughout the Aleutians but in only a few isolated patches east of about 168 degrees W longitude (Umnak Island). Their highest CPUE was in the western Aleutians near Kiska, Agattu, and Amchitka Islands and in the eastern Aleutians near Amilia, Umnak, Atka, and Tanaga Islands.

Soft corals were found throughout the Aleutians and in the eastern Bering Seashelf area, including Norton Sound, but only in isolated patches of the GOA. There was little variation in CPUE among the locations where soft coral was found. Soft corals were also found in the northeastern section of the Chukchi Sea.

The range of distribution of the various corals indicated by the survey generally followed that of Cimberg, *op. cit.* with some notable exceptions (Figures 3 and 4). Cimberg, *op. cit.* implied a much more patchy distribution of corals in Alaska than did the surveys; their patchy distribution was due to their few samples. The trawl survey in general did not include inside waters of southeastern Alaska, an area where Cimberg, *op. cit.* recorded a substantial portion of gorgonian corals, hydrocorals, and cup corals. Cimberg, *op. cit.* also showed that the distribution of soft coral extended north

to the Arctic Ocean into the Beaufort Sea. The survey indicated that cup corals are more prevalent than Cimberg, *op. cit.* indicated and their distribution extends westward throughout the Aleutian Islands.

In general, the taxonomic list based on the survey data agreed with Cimberg, *op. cit.*, with some notable exceptions (Tables 1 and 2). Soft corals in the genus *Anthomastus* were missing from Cimberg, *op. cit.* This soft coral is found mostly in Aleutians Islands and has been verified (Dr. B. L. Wing, NMFS, Auke Bay Laboratory, Juneau AK, pers. com.). The gorgonian corals listed as *Calcigorgia* sp. and *Calcigorgia spiculifera* were missing from Cimberg, *op. cit.* These corals were also mostly found in the Aleutians Islands and have been verified (Dr. B. L. Wing, *op. cit.*). The gorgonian sea fans in the genus *Fanellia* in the survey data but missing from Cimberg, *op. cit.* are synonymous with *Callogorgia*, which occurs in both lists. The gorgonian in the genus *Amphilaphis* found mostly in the Aleutians was missing from Cimberg, *op. cit.* *Amphilaphis* was verified by Dr. F. M. Bayer at the Smithsonian Institute (Dr. J. W. Orr, NMFS, Seattle, WA, pers. com.). The cup coral *Javania borealis* and the hydrocoral *Cyclohelix lanceolata* missing from Cimberg, *op. cit.* were described as species after their list was prepared (Cairns, 1994). Missing from the survey list were the gorgonian bamboo coral *Lepidisis paucispinosa*, hydrocoral in the genus *Allopora*, and the cup corals *Balanophyllia elegans* and *Caryophyllia alaskensis*. *Lepidisis paucispinosa* may be a rare species in Alaska or perhaps misidentified in Cimberg, *op. cit.* (Dr. B. L. Wing, *op. cit.*). *Allopora* is synonymous with *Stylaster* (Cairns, 1983). *Balanophyllia elegans* and *Caryophyllia alaskensis* are usually found in shallow or intertidal waters, which are not sampled by the survey.

In general, except for soft coral, the type of commercially valuable fish found in association with corals was similar (Figure 5). For gorgonian coral, hydrocoral, and cup corals, the CPUE of commercial fish species was made up mostly of rockfish and Atka mackerel. Rockfish made up 37%, 45%, and 25% of the CPUE for gorgonian corals, hydrocorals, and cup corals, respectively. Atka mackerel made up 29%, 29%, and 30% of the CPUE for gorgonian corals, hydrocorals, and cup corals, respectively. Only 4% of the CPUE for soft corals included Atka mackerel and rockfish. For soft corals, most of the CPUE of commercial fish species was made up of flatfish (67%) and gadids (27%).

In summary, the trawl survey data provides valuable information on the distribution and abundance of coral in Alaska, and the fish associated with them. A

question that arises when working with these data is their consistency. Scientists on the research cruises are instructed to record a specimen only to the taxonomic level they are sure about. Thus, there are a variety of taxonomic levels in the data base. Recently, pictorial guides have been prepared that aid scientists in their field identifications (e.g., Clark, 1999), and specimens are often brought back from the field, where they can be verified. Thus, improvement in the quality of this information is expected, which should help managers make rational decisions for the conservation and protection of corals in Alaska.

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Table 1. List of taxonomic names and frequency of occurrence for corals in NMFS trawl surveys in Alaska, 1975 - 1998.

Name	Frequency			Total
	Aleutians	Bering Sea	Gulf of Alaska	
Coral unidentified	101	6	23	130
Soft				
Alcyonacea (order)	77	119	5	201
<i>Alcyonium</i> sp.	1	0	0	1
<i>Alyconaria</i> unidentified	1	1	1	3
<i>Anthomastus</i> sp.	43	0	0	43
<i>Anthomastus</i> sp. A (red)	1	0	0	1
<i>Anthomastus</i> sp. B (gray)	1	0	0	1
<i>Gersemia rubiformis</i> (=Eunephthya rubiformis)	0	157	0	157
<i>Gersemia</i> sp. (=Eunephthya sp.)	18	1,568	13	1,599
Gorgonian				
<i>Amphilaphis</i> sp.	27	0	4	31
<i>Amphilaphis</i> sp. 1	1	0	0	1
<i>Amphilaphis</i> sp. 2	16	0	0	16
<i>Amphilaphis</i> sp. 3	15	0	0	15
<i>Arthrogorgia</i> sp.	70	0	0	70
<i>Calcigorgia</i> sp.	11	0	1	12
<i>Calcigorgia spiculifera</i>	13	0	0	13
<i>Callogorgia</i> sp.	142	0	22	164
<i>Fanellia compressa</i>	11	0	8	19
<i>Fanellia fraseri</i>	30	0	0	30
<i>Fanellia</i> sp.	2	0	0	2
<i>Keratoisis</i> sp.	2	0	0	2
<i>Muriceides</i> sp.	7	0	0	7
<i>Paragorgia arborea</i>	81	1	1	83
<i>Paragorgia</i> sp.	22	3	0	25
<i>Plumarella</i> sp. 1	29	0	0	29
<i>Primnoa</i> sp.	25	0	3	28
<i>Primnoa willeyi</i>	112	0	40	152
<i>Thouarella</i> sp.	79	0	0	79
Cup				
<i>Caryophyllia alaskensis</i>	5	0	0	5
<i>Caryophyllia</i> sp.	14	0	0	14
<i>Javania borealia</i>	9	0	0	9
Scleractinia unidentified	175	20	58	253
Hydrocoral				
<i>Cryptelia trophostega</i>	42	0	0	42
<i>Cyclohelix lancellata</i>	53	0	0	53
<i>Distichopora</i> sp.	23	0	0	23
<i>Errinopora nanneca</i>	9	0	0	9
<i>Errinopora</i> sp.	16	0	0	16
<i>Errinopora zarhyncha</i>	3	0	0	3
<i>Stylaster brochi</i>	4	0	1	5
<i>Stylaster cancellatus</i>	8	0	0	8
<i>Stylaster polyorchis</i>	2	0	0	2
<i>Stylaster</i> sp.	81	0	6	87
<i>Stylaster verrilli</i>	1	0	0	1
Stylasterina unidentified	1	0	0	1

Table 2. List of taxonomic names for corals in Alaska based on Cimberg, et al. (1981).

Soft Coral

Gersemia rubiformis

Gorgonian coral

Arthrogorgia kinoshitai

Arthrogorgia otsukai

Calligorgia compressa

Keratoisis profunda

Lepidisis paucispinosa

Muriceides cylindria

Muriceides nigra

Paragorgia arborea

Paragorgia pacifica

Paragorgia sp.

Plumarella flabellata

Plumarella spicata

Plumarella spinosa

Plumarella sp.

Primnoa reseaeformis

Primnoa willeyi

Swiftia beringi

Swiftia pacifica

Thouarella higendorfi

Thouarella straita

Cup coral

Balanophyllia elegans

Caryophyllia alaskensis

Hydrocoral

Allopora campyleca

Allopora campyleca paragea

Allopora campyleca trachystoma

Allopora campyleca tylota

Allopora moseleyana

Allopora papillosa

Allopora petrogapta

Allopora polyorchis

Allopora spp.

Cryptelia trophostega

Distichopora borealis

Errionopora nanneca

Errionopora zarhyncha

Stylaster cancellatus

Stylaster elassotomus

Stylaster gemmascens alaskanus

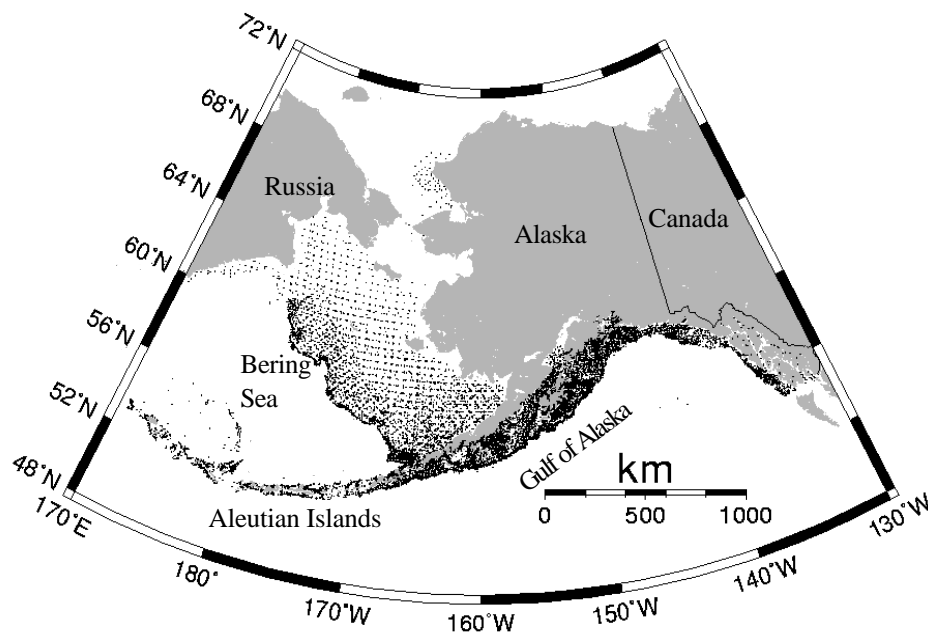


Figure 1. Location of NMFS bottom trawl hauls off Alaska, 1975 - 1998.

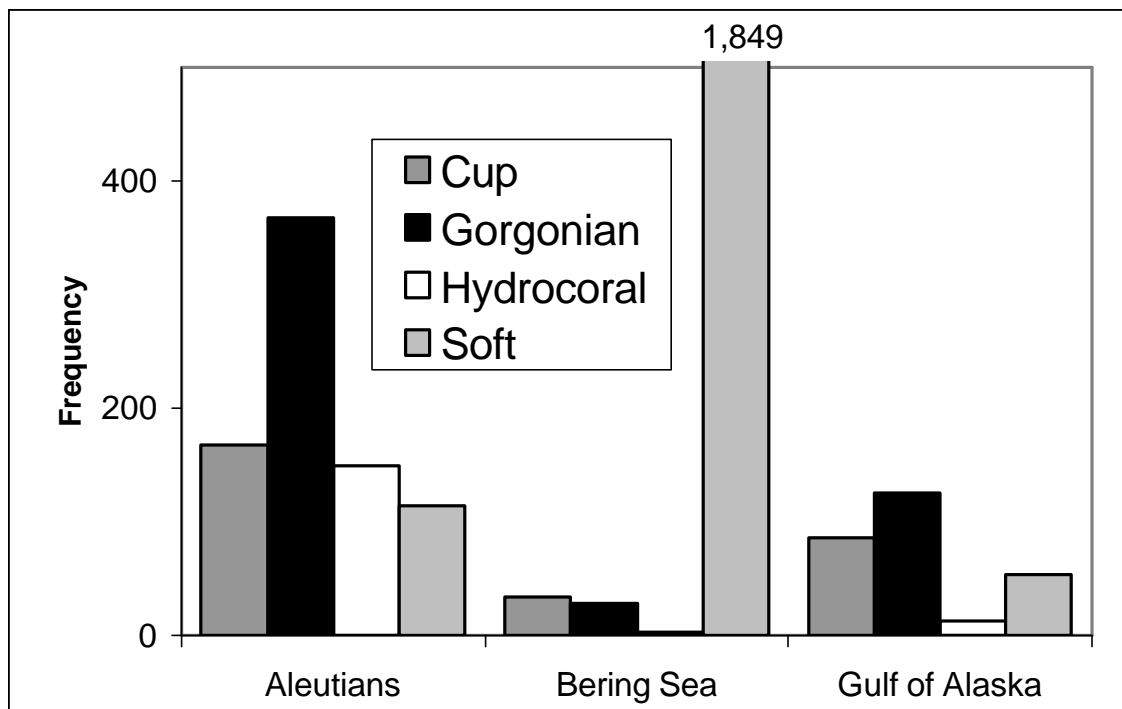


Figure 2. Frequency of occurrence of taxonomic groups of corals by geographic area of Alaska based on trawl survey data, 1975 - 1998.

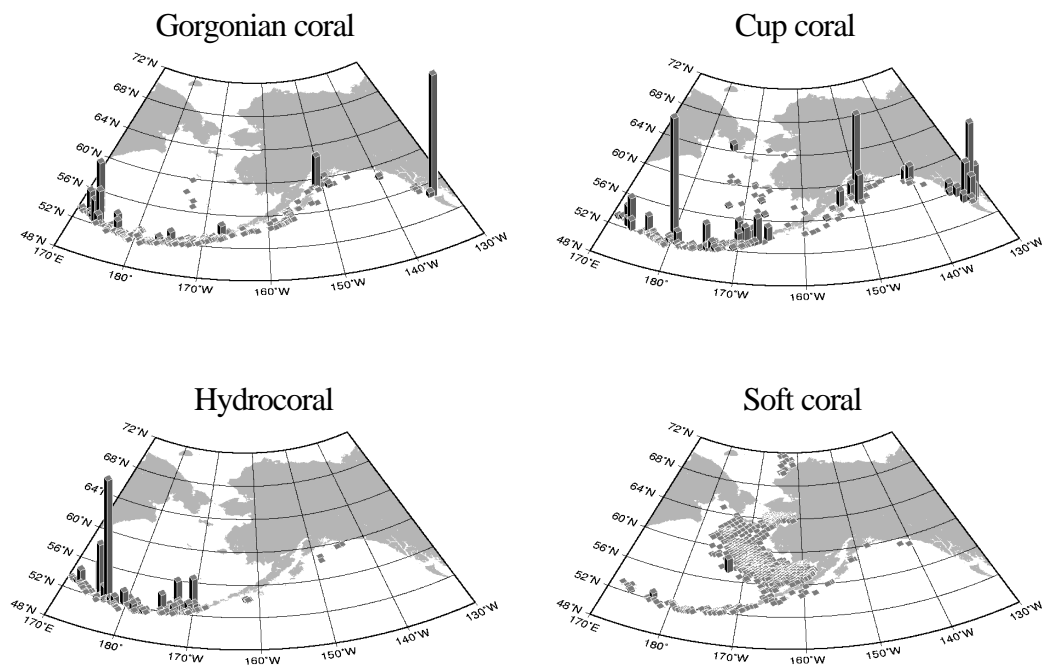


Figure 3. Relative abundance within a taxonomic group of corals off Alaska based on CPUE in NMFS trawl surveys, 1975 - 1998. Within a taxonomic group, CPUE was scaled relative to the largest value.

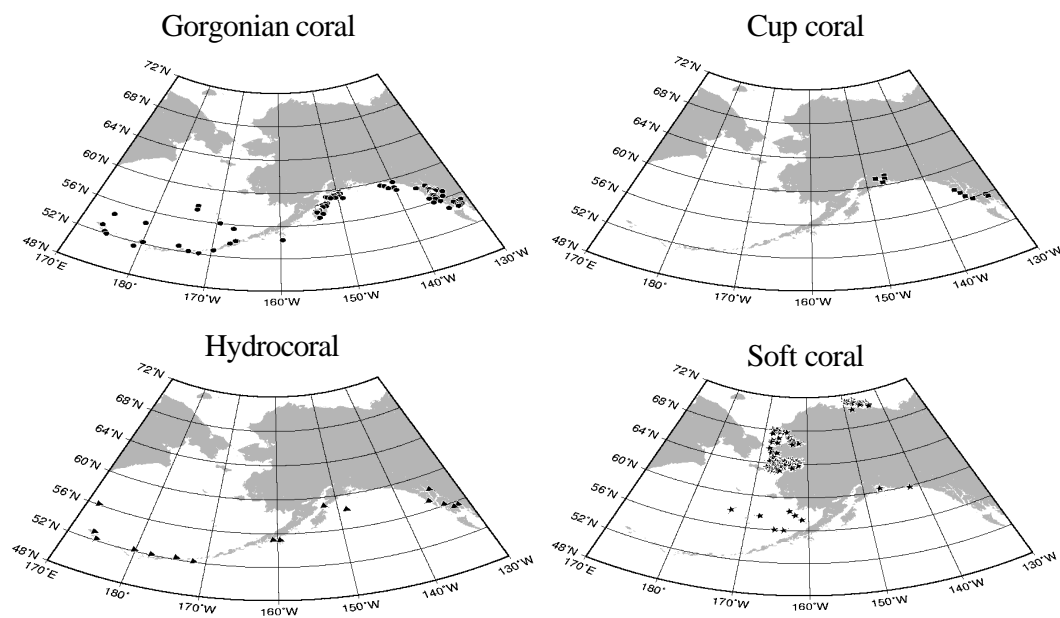


Figure 4. Locations of corals off Alaska based on Cimberg et al. (1981).

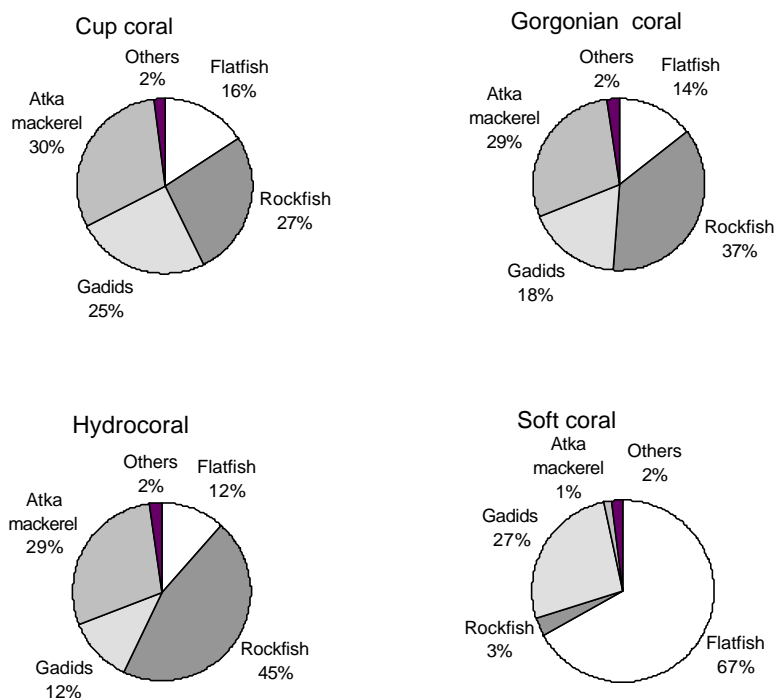


Figure 5. Commercial fish groups associated with corals based on NMFS trawl surveys, 1975 - 1998. Within a coral group, percentages are based on the proportion of the total fish CPUE that was attributable to a particular fish group.